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ANALYSIS OF DEMANDS ON THE NAVAL AIR REWORK FACILITY, NORTH ISL--ETC(U)
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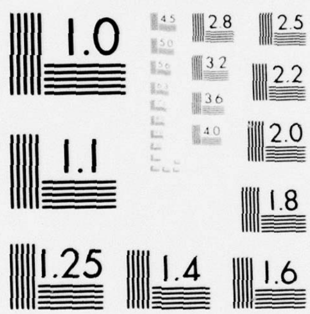

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ANALYSIS OF DEMANDS ON THE NAVAL AIR REWORK FACILITY, NORTH ISLAND

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ANALYSIS OF DEMANDS ON THE NAVAL AIR REWORK FACILITY, NORTH ISLAND

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In developing a system for allocating manpower resources in the Navy, major emphasis has been placed on the design of an input-output model to forecast the workload of shore activities, based on the size and distribution of the fleet. To determine the feasibility of an input-output analysis for operational use, a full-scale model of the 11th Naval District is being developed. The structure of input-output analysis requires data on the work output of each shore activity and its destination in the fleet and other

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shore activities. In addition, the demands by the fleet must be disaggregated by ship type/aircraft model, movement, and status.

A major effort is underway to collect and organize data and to conduct an empirical analysis of the fleet-shore workload demand network, focusing on 12 major shore activities in the 11th Naval District. This report concerns the analysis of workload demands on one of these shore activities--the Naval Air Rework Facility, North Island.

The structure of demands on the Naval Air Rework Facility, North Island was analyzed by using production load norms, induction and completion schedules, "carry-overs," and actual man-hour expenditures, obtained quarterly for FY75 and FY76 from Fleet Support Conference packages prepared by the Naval Air Systems Command Representative, Pacific (NAVAIRSYSCOMREPAC). The data were used to determine the distribution of total workload and differences in demand among aircraft models, engine models, and repair categories.

FOREWORD

The effort described in this report supports the Fleet Impact on Shore Requirements, an advanced development under Navy Decision Coordinating Paper, Manpower Requirements Development System (NDCP-Z0109-PN). The overall objective of this subproject is to apply econometric and manpower modelling technologies in the prediction and allocation of shore activity level manpower resources as a function of workload and operational force levels. The main effort of FY77 is an empirical study of the fleet and shore demands placed on major shore activities in the 11th Naval District, with the objective of developing an input-output (I/O) model of the fleet-support demand network. This report focuses on one of the major shore activities, the Naval Air Rework Facility, North Island.

Achnowledgements are due to Mr. P. Westbrook (Workload Coordination Branch) of the Naval Air Systems Command Representative, Pacific (NAVAIRSYSCOMREPAC); Mr. R. Grandmaison (Workload Coordinator) of the Naval Air Rework Facility, North Island (NARFNI); and Mr. F. Lodge (Depot Management Division) of the Naval Air Systems Command (NAVAIR). The entire staff of NARFNI, NAVAIR, and NAVAIRSYSCOMREPAC were extremely helpful and cooperative throughout the data collection and analysis stages of this study.

J. J. CLARKIN
Commanding Officer

SUMMARY

Problem

A system for determining Navy manpower requirements and allocating manpower resources must be based on the workload and economic relations among individual shore-support activities. The demand network that links shore activities to one another, and to the fleet, constitutes the economic system of the Navy. To represent this network structure, an input-output (I/O) model of the 11th Naval District is being developed to forecast the workload of shore activities, based on the size and distribution of the fleet. An I/O model of this size requires a significant effort to collect, organize, and analyze data on the source and intensity of demands.

Objective

This report analyzes workload demands placed on the Naval Air Rework Facility, North Island (NARFNI) by fleet and reserve activities. The results will be used in developing a full-scale model of the fleet-support demand network of the 11th Naval District.

Approach

The structure of demands on NARFNI was analyzed by using production load norms, induction and completion schedules, "carry-overs," and actual man-hour expenditures obtained quarterly for FY75 and FY76 from Fleet Support Conference packages prepared by the Naval Air Systems Command Representative, Pacific (NAVAIRSYSCOMREPAC). The data were used to determine the distribution of total workload and differences in demand among aircraft models, engine models, and repair categories.

Findings

NARFNI produces output that can be classified into four major categories: Aircraft Rework, Engine Rework, Component Rework, and Other Support. Fleet demand on NARFNI, in terms of aircraft and engines, was found to differ significantly by model and rework category. Aircraft rework at NARFNI is specialized in the maintenance, modification, and conversion of F-4 fighters, E-2 early warning aircraft, and CH-46 and CH-53 helicopters. The F-4 aircraft models were found to dominate the workload, accounting for over 75 percent of total aircraft rework at NARFNI in FY75 and FY76. The Standard Depot Level Maintenance/Conversion program is by far the largest aircraft repair category, representing about 62 percent of the total aircraft repair man-hours.

Unlike demand for Aircraft and Engine Rework, demand for Component Rework and Other Support could not be disaggregated. However, reasonable estimates for both outputs were obtained from recent historical data. Estimates for all four workload areas, based on recent historical data, averaged only a 3 percent error when compared with actual data.

Conclusions

1. Naval air rework workload data is available to measure demands on NARFs in terms of man-hours expended in rework. This data will easily conform to an I/O framework.

2. The aircraft or engine model and the kind of repair performed affected demands placed on NARFNI. An I/O model that includes these demands must stress the resulting differences in workload.

3. Despite the large number of different aircraft, engines, components, and other support functions, these can be aggregated into 35 aircraft sectors, 25 engine sectors, 1 component rework sector, and 1 other support sector in an I/O model.

4. Since NARFs are technically specialized, changing the homeport of three aircraft carriers from San Diego to Alameda is not likely to affect aircraft rework at NARFNI. However, an increase or decrease of three aircraft carriers Navy-wide is certain to influence workload at NARFNI. An I/O model must have the ability to quantitatively determine this influence on workload.

Recommendations

This analysis should be extended to include all six Naval Air Rework Facilities. Close liaison should be maintained with the Naval Air Systems Command when the entire NARF System is incorporated into the Navy-wide I/O model.

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INTRODUCTION

Problem

The design of a system to determine the Navy's manpower requirements and allocate manpower resources has emphasized the development of an input-output (I/O) model to forecast the workload of shore activities based on the size and configuration of the fleet. Manpower requirements are then derived from workload forecasts. The I/O structure will link the activities of the fleet to individual shore-support activities and indicate linkages among those shore-support activities. With the interconnections among fleet and shore activities identified, methods can be developed to quantitatively measure the relationship of workload demands on the operating forces and shore-supporting activities.

The I/O model may be able to answer a wide variety of Navy management questions, such as:

1. For changes in fleet size or mix, what alterations in workload can be expected at each shore activity?

2. What is the impact of changes in the shore establishment on the level of fleet support?

3. If ships are transferred from one homeport to another, what will be the effect on activities at each port?

An I/O model representing the fleet-support demand network of the 11th Naval District (11ND) is being developed for use by Navy managers. It requires data on the output of each shore activity and its destination in the fleet and other shore activities. Demands by the fleet must be broken out by ship type and aircraft model and by their movement and status. A large data base is essential to an I/O model, so current efforts are devoted to collecting, organizing, and analyzing data for use in describing a fleet-support demand network.

Purpose

This data analysis effort focuses on workload demands placed on 12 11ND shore activities.[1] These activities were selected for their wide range of functions, outputs, and data problems; their manpower intensities, and their direct and indirect linkages to the fleet. Furthermore, they comprise nearly 45 percent of the total 11ND workforce.

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[1]The activities are the Naval Supply Center, San Diego; Long Beach Naval Shipyard; Naval Air Stations, North Island and Miramar; Naval Regional Medical Center, San Diego; Naval Training Center, San Diego; Naval Station, San Diego; Public Works Center, San Diego; Naval Electronics Laboratory Center, San Diego; Naval Electronic Systems Engineering Center, San Diego; Development and Training Center, San Diego; and the Naval Air Rework Facility, North Island.

The purpose of this report is to provide an analysis of workload demand on one of these activities--the Naval Air Rework Facility, North Island (NARFNI).[2] NARFNI is directly responsible for all major maintenance, incorporation of technical changes, and repair of damage for, primarily, West Coast-based Navy F-4, C-2, and E-2 aircraft and an assortment of helicopters, engines, and aeronautical and ground support components. As the largest of the six such facilities, NARFNI employs about 7000 civilians.

Background

The workload at each NARF is constrained by the total budget of the NARF system and is dynamically influenced by the level and configuration of workload at the others. Consequently, it would be misleading to study NARFNI outside a NARF system context.

The Depot Management Division of the Naval Air Systems Command (NAVAIR 414) manages the budget and resources for the total NARF system by producing workload assignments and schedules for each facility after receiving rework requirements for aircraft and engines from the Chief of Naval Operations, the "owner" of this equipment. These requirements are based on flying time and derived engine hours. Normally, there is a 2- to 3-year period between regular depot-level rework on a given equipment.

Before an aircraft or engine is inducted into a maintenance cycle at a NARF, an estimate of norm is obtained, based on historical data of man-hours needed to repair and modernize that type of equipment. It is hoped that the aircraft or engine will enter the NARF on time and use exactly the number of man-hours specified by the norm.

Component rework requirements are produced by the Aircraft Supply Office (ASO). Components have complex repair requirements based on their "mean time-to-failure" rates and operating specifications. This information and recent historical data are used to derive component norms.

These requirements, along with their associated norms, are input into NAVAIR's Long Range Planning Model (LRPM). This model, with a 5-year horizon, analyzes workload by the (1) type, model, and series (TMS) of an aircraft, engine, and component, (2) repair category, (3) production shop, (4) customer, and (5) funding source. It is both a financial and physical workload planning tool. Its output is used not only for scheduling, but also for the Program Objectives Memorandum (POM) cycle, the Navy Resource Model (NARM), and the mobilization scenarios. Normally, not all of the requirements for a fiscal year are satisfied. Work is frequently deferred due to budget limitations.

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[2] This is the third in a series of reports on the empirical study of demands placed on 11th Naval District shore activities. The first two were Blanco, T., Analysis of fleet and shore demands on the Naval Supply Center, San Diego (NPRDC Tech. Rep. 76TQ-39), San Diego: Navy Personnel Research and Development Center, June 1976; and Rowe, M., Analysis of demands on the Long Beach Naval Shipyard (NPRDC Tech. Rep. 77-7), San Diego: Navy Personnel Research and Development Center, December 1976.

Work that is not deferred is distributed according to (1) the technical specializations of the various NARFs and private facilities, (2) the current and future location of the equipment, and (3) the capacity of each NARF.

Between the planning stage and the completion of scheduled work on an aircraft, many events can affect the predicted workload requirement of a NARF. For example, estimated man-hours required can be altered by updated funding information, carrier deployment, DoD regulations regarding Navy facility/private facility workload ratios, minimum utilization rates (single shift + "x" overtime), extensions (deferred work), and balancing between NARFs. Because of these changing constraints, the balance between the assignment of equipment for rework and the man-hours actually expended at a NARF becomes an iterative, "smoothing" process.

Although workload requirements change frequently at NARFs, workload capacity can change even more dramatically. The prime determinant of workload capacity is the budget, and the level of funds allocated to the NARF system often fluctuates greatly during a fiscal year. It is not uncommon for a NARF to experience a decrease in the flow of funds and than a sudden increase during a given fiscal quarter. Induction schedules have to be adjusted to reflect these budget changes.

APPROACH

Data Sources and Initial Processing

Analysis of the workload demands placed on NARFNI and the development of techniques to estimate those demands require pooling several groups of data. Thus, production load norms, induction schedules, completion schedules, "carry-overs," and actual man-hour expenditures were obtained quarterly for FY75 and FY76 from the Fleet Support Conference package prepared by the Naval Air Systems Command Representative, Pacific (NAVAIRSYSCOMREPAC). Information on the position of NARFNI in the Naval Air Rework System was derived from the Industrial Performance Summary for Naval Air Rework Facilities, an annual publication of NAVAIR 414. Data were collected on a fiscal year basis in terms of "man-hours expended" on all work being performed at NARFNI.

"Man-hours expended" in rework was selected as the workload measure rather than such alternatives as "the number of aircraft, engines, etc. in the facility" for several reasons. The latter does not, for example, distinguish between the workload required to complete a regular maintenance program on a CH-53 helicopter and a model conversion on an F-4 aircraft. Nor does it reflect the proportion of workload that is service-oriented or in support of the rework lines. Also, NARFNI and NAVAIR 414 already use "man-hours expended" as their workload indicators for planning and scheduling.

Because the data permit an analysis of the demands on NARFNI in terms of individual customers, they can be used to determine the proportion of total demand from each major workload area, aircraft and engine model, and repair category, as well as the differences in workloads for different models and kind of repair.

Initial processing involved calculating the distribution of total NARFNI workload among the four major workload areas--Aircraft Rework, Engine Rework, Component Rework, and Other Support (O/S)--and then determining the configuration of work within each.

Analysis of Demands

The analysis of aircraft demand on NARFNI focused on the aircraft model and the kind of repair performed as indicators of the source and intensity of demand. The aircraft workload mix at NARFNI is dominated by F-4, E-2, C-2, H-46, and H-53 aircraft because of its specialization in the overhaul, conversion, and modernization of these aircraft types.

Aircraft workload was measured by production load norms, which are an estimate of the man-hours required for NARFNI to perform a specific work package. Most work is performed on a fixed-price basis, so the norms that are derived from this price are generally an accurate measure of what work is completed. Instead of calculating average demand rates and standard deviations for each aircraft model and repair category, norms are used as the measure of aircraft demand (Appendix A displays FY75 and FY76 aircraft norms for NARFNI). Since norms are revised frequently due to changes in funding allowances and technical specifications, only the most recent norms are applicable.

Some aircraft models could possibly have been grouped into categories defined by similar or equal norms. However, even with identical norms, these aircraft models would not necessarily fall into an identical demand group for other repair categories or for outputs other than "man-hours expended in aircraft rework." Consequently, analysis by aircraft model and by repair category was maintained throughout this study.

While a norm is a relatively accurate measure of the man-hours that will actually be expended on a particular aircraft, forecasting the total workload for all aircraft in a fiscal year is difficult and susceptible to large errors. The actual and planned workload figures often differ widely because of (1) deployment changes that influence induction schedules, (2) deferrals from the previous year or to the next year, and/or, (3) alterations in funding, overtime agreements, and workload balances between NARFs. The total workload also is affected by unexpected problems such as a lack of skilled workers, a series of crash-damaged aircraft requiring more than routine repair, or aircraft that simply require more than the anticipated man-hours. Nevertheless, several methods have been developed to forecast aircraft workload. Each estimates total aircraft workload at NARFNI for FY75 and FY76 and compares these estimates to the actual figures for those years to determine their relative efficiency.

As with aircraft, the analysis of engine rework demands on NARFNI stressed the model and the kind of repair accomplished. The workload can also be measured by man-hour norms (Appendix B contains FY75 and FY76 engine norms for NARFNI). Although the estimation of total engine workload for NARFNI in a fiscal year encounters problems similar to that of estimating aircraft workload, several methods for predicting that workload were developed.

Accurate estimates of the workload attributable to component rework are difficult to obtain because of (1) the large number of different components, (2) their diverse and complicated repair cycles (based on expected life-span and mean time-to-failure estimates), and (3) changing repair funding. Furthermore, components are generally "single-sited" (that is, one NARF generally reworks all of a particular component) and are rarely influenced by local fleet size, configuration, or movement. Consequently, it is difficult to determine exactly what drives the component workload at a particular NARF and, thus, to forecast that workload.

Although many of the 40 Other Support (O/S) workload categories are driven by local demand, aircraft, engines, and/or components in the area or actually on-site at the NARF, it nevertheless is difficult to forecast O/S workload. Two of the largest O/S categories during FY76 were Other Navy Activities and NAVAIR Tasks, which include so many independent functions that it becomes formidable to determine the sources of demand for this work. Many of the smaller categories are equally complex. When a category is tied directly or indirectly to the current or future workload at a NARF (e.g., the F-4 Beeline Manufacturing and the F-4B/N conversion programs), a quantitative relationship may be possible, but is often laborious, to obtain.

RESULTS

Total production man-hours at NARFNI were virtually unchanged between FY75 (6,962,000) and FY76 (6,963,000).[3] Table 1 indicates the distribution of that workload among the four major workload categories.

Table 1

Distribution of Workload by Major Areas, NARFNI, FY75--76

Workload Area	Proportion of Workload (%) FY75	FY76
Aircraft	36.9	36.4
Engines	9.6	7.5
Components	23.7	24.4
Other Support	29.8	31.7
Total	100.0	100.0

Aircraft Demand

The initial processing of aircraft maintenance data involved isolating the demand of each model for each kind of repair. The largest aircraft repair category was Standard Depot Level Maintenance/Conversion (SDLM/Conversion), which required 62 percent of the aircraft workload in FY76. All of this work was attributable to the conversion of F-4Bs to F-4Ns (F-4B/N). Table 2 indicates the distribution of aircraft rework among the five categories used at NARFNI.

[3]Aircraft Condition Evaluation (ACE) was discontinued in mid FY76. To make the two observed years comparable, ACE has been excluded.

Table 2

Distribution of Aircraft Rework by Repair Category, NARFNI, FY75--76

Repair Category	Proportion of Aircraft Workload (%) FY75	FY76
SDLM/Conversion	66.0	62.0
SDLM/Modification	11.0	6.0
SDLM/Regular	20.0	30.0
SDLM/Mod/Repair	1.0	0.0
SDLM/Reserve	2.0	2.0
Total	100.00	100.0

Note. This distribution of workload was calculated from an estimate of FY75 and FY76 aircraft workload (see method A-1, page 12).

For the two observed years, at least 88 percent of aircraft workload was derived from only two aircraft types, E-2 and F-4, while the F-4B/N accounted for a minimum of 62 percent. Table 3 displays the distribution of aircraft maintenance workload by aircraft model.

While the regular SDLM program consumed 30 percent of aircraft workload in FY76, E-2Bs and F-4Ns dominated this category with over 54 percent of the workload. Finally, SDLM/Modification was entirely reserved for the modernization of F-4J aircraft.

Of equal importance to the total man-hours expended during a repair cycle is the distribution of the workload over that cycle. The norm, or the average percentage contribution to the total workload, for each week of a repair cycle is available for all aircraft and engines in a workload "profile." The profiles for three of the largest SDLM customers (F-4J, F-4N, and C-2A) reveal similar workload distribution characteristics. All three models complete at least 60 percent of the rework in the first half of the cycle, while peak workload occurs in the 5th to 7th month of a 13- to 22-month SDLM cycle. Figure 1 displays the distribution of workload (in percentages) over the SDLM cycle for these models.

Table 3

Distribution of Aircraft Rework by
Aircraft Model, NARFNI, FY75--76

Model	Proportion of Aircraft Workload (%)	
	FY75	FY76
E-2B	14.4	12.6
E-2C	0.0	0.9
TE-2A	0.3	0.3
TE-2C	0.0	0.3
C-2A	0.9	0.9
CH-46A	0.2	0.2
CH-46D (Reserve)	0.2	1.1
CH-46D	1.1	0.9
CH-46F	0.5	2.1
CH-53A (Reserve)	1.8	0.8
CH-53A	2.6	1.6
CH-53D	0.7	2.1
RH-53D	0.0	0.5
SH-3A	0.0	0.3
F-4J	11.0	8.7
F-4B/N	66.0	61.5
RF-4B	0.4	1.4
F-4N	0.0	3.7
Total	100.1	99.9

Notes. 1. This distribution of workload was calculated from an estimate of FY75 and FY76 aircraft workload (see method A-1, page 12).

2. Due to rounding errors, totals do not equal 100 percent.

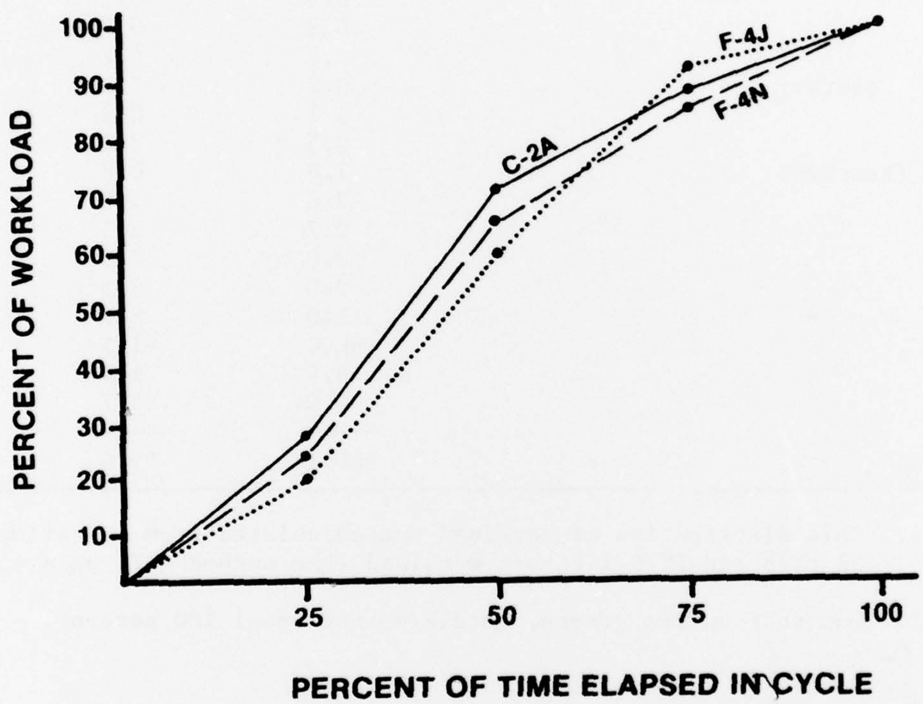

Figure 1. Cumulative percentage workload distribution for selected stages of SDLM cycle.

Three methods were developed to estimate total aircraft workload at NARFNI for FY75 and FY76. Table 4 displays the estimates from each method and compares them to the actual figures.

Table 4

Estimates of Aircraft Workload, NARFNI
(Man-hours in Thousands)

Estimating Method	Workload FY75	% Error From Actual	Workload FY76	% Error From Actual
A-1	2579	0.4	2593	2.3
A-2	2173	15.4	2351	7.2
A-3	2760	7.2	2567	1.3
Actual	2567	--	2534	--

The first estimating method, A-1, multiplies a matrix of norms (AN_{ijt}) by a matrix of inductions (AI_{ijt}) for each year and adds in an estimated "carry-in" total (CIN_t).[4] (During FY75, there was a major revamping of aircraft rework specifications. The basic rework package was changed from a Progressive Aircraft Rework (PAR) to a Standard Depot Level Maintenance (SDLM). This involved a large change in norms for many aircraft. Since the change occurred in mid-year, a simple average of A-1 using first SDLM and then PAR norms is used as the A-1 estimate of FY75 aircraft workload.)

The second method, A-2, required multiplying norms (AN_{ijt}) by a matrix of planned completions (AC_{ijt}) (rework started <u>and</u> finished during the year) and adding in estimated carry-ins/carry-outs (CIN_t, $COUT_t$).

A final, "naive" method, A-3, suggested that workload this year would be what it was the previous year.

[4]"Carry-outs" (carry-ins) refer to man-hours expended this year on jobs that began in the current (previous) year, but are finished in the next (current) year. Carry-in (carry-out) man-hours were estimated by multiplying each carry-in (carry-out) aircraft by its norm and then dividing by 2. This leaves half of the workload in the previous (following) year and half in the current year. Since the actual carry-over may be anywhere from a few man-hours to several thousand, this "average" is a reasonable estimate.

The formulations of the methods are:

$$\underline{A\text{-}1}: \quad AW_t = \sum_{i=1}^{m} \sum_{j=1}^{n} AN_{ijt}AI_{ijt} + CIN_t$$

$$\underline{A\text{-}2}: \quad AW_t = \sum_{i=1}^{m} \sum_{j=1}^{n} AN_{ijt}AC_{ijt} + CIN_t + COUT_t$$

$$\underline{A\text{-}3}: \quad AW_t = AW_{t-1},$$

where

m = number of aircraft models;

n = number of repair categories;

AW_t = aircraft workload, NARFNI, fiscal year $\underline{t}$;

AW_{t-1} = aircraft workload, NARFNI, fiscal year $\underline{t}$-1;

AN_{ijt} = production load norm for aircraft model $\underline{i}$, repair category $\underline{j}$, and fiscal year $\underline{t}$;

AI_{ijt} = inductions for aircraft model $\underline{i}$, repair category $\underline{j}$, and fiscal year $\underline{t}$;

AC_{ijt} = completions for aircraft model $\underline{i}$, repair category $\underline{j}$, and fiscal year $\underline{t}$;

CIN_t = carry-in workload, fiscal year $\underline{t}$; and

$COUT_t$ = carry-out workload, fiscal year $\underline{t}$.

While both A-1 and A-3 appear to provide relatively good estimates of FY75 and FY76 aircraft workload, A-1 is probably more appropriate. The A-3 method bases its estimate of current year workload on the norms and configuration of the preceding year, while A-1 embodies current knowledge. Only if norms and the configuration of workload do not change significantly from one year to the next will A-3 provide a reasonable estimate. The accuracy of A-1 also emphasizes the ability of production load norms to describe the demands placed on NARFNI by various aircraft models.

Engine Demand

The largest category of engine rework was Repair Supply (O&MN-funded), which comprised 34 percent of NARFNI engine workload in FY76. The three O&MN-funded categories together required 74 percent of the total engine man-hours. Table 5 shows the contribution to NARFNI engine workload of each of the eight engine repair categories.

Of the 16 different engine models reworked during FY76, four--J79GE8, J79GE10, T58GE8F, and T58GE10--consumed 75 percent of the man-hours expended in engine rework. The two J79 models alone required 62 percent. The J79GE10 was the largest customer in each of the three largest repair categories, using 42 percent, 36 percent and 79 percent of the workload in O&MN Overhaul, Repair Supply, and Repair Mid-Span, respectively.

Table 5

Distribution of Engine Workload by Repair Category, NARFNI, FY75--76

	Proportion of Engine Workload (%)[a]	
Repair Category	FY75[b]	FY76
Overhaul (O&MN)	69.3	21.2
Overhaul (Reserve)	5.5	6.1
Overhaul (Other)	5.5	7.6
Repair Supply (O&MN)	13.0	34.1
Repair Supply (Reserve)	4.0	6.7
Repair Supply (Other)	2.1	4.0
Repair Mid-Span (O&MN)	0.0	18.3
Repair Mid-Span (Reserve)	0.0	1.7
Total	99.9	99.7

Note. Due to rounding errors, totals do not equal 100 percent.

[a]This distribution of engine workload was calculated from an estimate of FY75 and FY76 engine workload (see Method E-2, page 14).

[b]Since FY75, the orientation of engines reworked changed. Fewer engines are totally overhauled, while more engines receive phased or "on-condition" (as required) maintenance.

Several methods for estimating engine workload have been developed. The first, E-1, multiplies the matrix of norms (EN_{ijt}) by the induction schedule (EI_{ijt}). Because engine norms are small and carry-in/carry-out workload is insignificant, an estimate of these carry-overs was not included in this method. The second technique, E-2, does account for carry-ins/carry-outs by adding the estimate of that workload ($CIN_t + COUT_t$) to the total of norms (EN_{ijt}) mulitplied by completions (EC_{ijt}). The final method, (E-3, simply maintains that the current year's workload will be the same as the preceding year. Table 6 contains the three total engine workload estimates for FY75 and FY76 and compares them to the actual man-hours.

Table 6

Estimates of Engine Workload, NARFNI
(Man-hours in Thousands)

Estimating Method	Workload FY75	% Error From Actual	Workload FY76	% Error From Actual
E-1	657	1.5	535	2.1
E-2	664	0.4	527	0.6
E-3	666	0.2	668	27.5
Actual	667	-	524	-

The methods are formulated as follows:

E-1: $$EW_t = \sum_{i=1}^{m} \sum_{j=1}^{n} EN_{ijt} EI_{ijt}$$

E-2: $$EW_t = \sum_{i=1}^{m} \sum_{j=1}^{n} EN_{ijt} EC_{ijt} + CIN_t + COUT_t$$

E-3: $$EW_t = EW_{t-1},$$

where,

m = number of engine models;

n = number of repair categories;

EW_t = engine workload, NARFNI, fiscal year t;

EW_{t-1} = engine workload, NARFNI, fiscal year $t-1$;

EN_{ijt} = production load norm for engine model i, repair category j, and fiscal year t;

EI_{ijt} = inductions for engine model i, repair category j, and fiscal year t;

EC_{ijt} = completions for engine model i, repair category j, and fiscal year t;

CIN_t = carry-in workload, fiscal year t; and

$COUT_t$ = carry-out workload, fiscal year t.

During the 2-year period, method E-2 provided the most consistent (and in FY76, the best) estimate of total workload at NARFNI. Method E-3 provided a poor estimate in FY76 because of the change in engine repair orientation, which substantially altered the number of engines in each repair category.

Component Rework Demand

Components repaired at NARFNI are largely from aircraft and engines. Because most components are single-sited (that is, one NARF usually reworks all of a particular component), they are generally drawn from the entire operating force. At least 74 percent of the man-hours expended on components were consumed in the Regular F/J category. The remaining workload was divided among either components attached to non-Navy customers or to miscellaneous ground support equipment.

In lieu of developing estimating methods that include all of the detailed information concerning failure rates and operating specifications, component repair workload can be adquately estimated from recent historical data (i.e., the previous year's workload). Table 7 demonstrates that the actual component repair workload value for FY75 is a reasonable estimate for FY76.

Table 7

Estimate of Component Rework Workload, NARFNI
(Man-hours, *thousands*)

	Workload FY75	% Error From Actual	Workload FY76	% Error From Actual
Estimate	1561	6.1	1659	1.6
Actual	1659	-	1687	-

Other Support Demand

Of the 40 Other Support (O/S) categories, 8 consumed 62 percent of that area's workload in FY76. The largest categories, Manufacturing (15.8%), Engineering Support (12.1%), F-4 Beeline Manufacturing (8.1%), and Aircraft Repair (4.8%) are tied directly or indirectly to current or future aircraft, engines, or components reworked at NARFNI or by field teams.

Instead of developing an estimating technique that includes knowledge of the many direct and indirect relationships between aircraft, engine, and component workload and certain categories, as well as information on changes in O/S funding, a method based on recent historical data is a tolerable "second-best" solution. Table 8 shows that the actual O/S workload for FY75 provides an estimate for FY76 with only a 2.3 percent error.

Table 8

Estimate of Other Support Workload, NARFNI
(Man-hours, Thousands)

	Workload FY75	% Error From Actual	Workload FY76	% Error From Actual
Estimate	2170	4.5	2073	2.3
Actual	2073	-	2121	-

CONCLUSIONS

The analysis of demands on the Naval Air Rework Facility, North Island (NARFNI) permits some general conclusions on the feasibility of building an I/O model of the fleet-support demand network.

1. Data exist in the naval air rework system to measure demands on NARFs in terms of man-hours expended in rework. These data will fit into an I/O framework, but analysis of the data is a laborious, time-consuming task. Close working relationships with members of NAVAIR's Depot Management Division, NAVAIRSYSCOMREPAC's Workload Coordination Branch, and NARFNI's Production Planning and Control Department are essential in interpreting the data.

2. With computer limitations and problems of data manageability, the number of sectors that can be effectively handled in an I/O model is an important question. While NARFNI had 295 aircraft customers and 897 engine customers and reworked thousands of components during FY76, these can be aggregated by model and repair category into approximately 35 aircraft sectors, 25 engine sectors, 1 component rework sector, and 1 other support sector. Whether those customers (aircraft models, etc.) will also turn out to be the major fleet sectors in a more comprehensive I/O model remains to be determined.

3. The results from this study can be used to develop input-output coefficients for the NARFNI sectors of the I/O model and can be used in combination with the results from analyses of demands of other major activities. For example, the I/O coefficient between NARFNI and the Naval Supply Center, San Diego might be measured in units of requisitions per man-hour of rework.

4. Since the aircraft and engine type and the kind of rework performed clearly affected the demands placed on NARFNI, the I/O model must not ignore the differences in repair workload resulting from different types of aircraft or repair categories.

5. Since NARFs are technically specialized, changing the homeport of three aircraft carriers from San Diego to Alameda is not likely to affect aircraft workload at NARFNI. However, an increase or decrease of three aircraft carriers Navy-wide is certain to influence that workload. An I/O model must therefore have the ability to quantitatively determine the influence that this type of change would have on workload.

RECOMMENDATIONS

This analysis should be extended to include all six Naval Air Rework Facilities. Close liaison should be maintained with the Naval Air Systems Command when the entire NARF System is incorporated into the Navy-wide input-output model.

APPENDIX A

NORMS (AVERAGE MAN-HOURS/MODEL AND REPAIR CATEGORY)
FOR AIRCRAFT AT NARFNI, FY75--76

APPENDIX A

Norms (Average Man-hours/Model and Repair Category)
for Aircraft at NARFNI, FY75--76
(In Man-hours)

Aircraft	SDLM		SDLM/ Repair		SDLM/ Modification		SDLM/MOD/ Repair		SDLM/ Conversion		SDLM/CON/ Repair		SDLM/ Reserve	
	75	76	75	76	75	76	75	76	75	76	75	76	75	76
E-2B	15500	15200	18700	19550										
E-2C	11100	11300												
TE-2A	8700	8700	13000	13500			13600							
TE-2C	8700	8700	13000	13500			13600							
C-2A		7900	11800	12700			15500							
CH-46A	3500	3200		3600										
CH-46D(R)[a]													3710	3600
CH-46D	3710	3200	4210	3600										
CH-46F	3410	3250	3910	3650										
CH-53A	3500	3600	4000	4700										
CH-53A(R)[a]													3500	4700
CH-53D	3100	3290	3600	3790										
RH-53D		3290		3790										
UH-53D		3508												
SH-3A		5100												
F-4J	8000	8000	12100	10000	13400	12400	16300	14400						
F-4B/N									30500	30100	31500	35100		
RF-4B	9500	7500	11300	8500										
F-4N		10600		12600										

Note. The norms reported here are SDLM norms. Although PAR norms were used in some FY75 aircraft workload estimates, they are no longer in effect.

[a]"R" designates U. S. Naval Reserve Aircraft.

APPENDIX B

NORMS (AVERAGE MAN-HOURS/MODEL AND REPAIR CATEGORY) FOR ENGINES AT NARFNI, FY75--76

APPENDIX B

Norms (Average Man-hours/Model and Repair Category)
for Engines at NARFNI, FY75--76, by Repair Category and Customer
(In Man-hours)

Engine Model	Overhaul Regular & Reserve		Repair Supply Regular & Reserve		Repair Mid Regular & Reserve		Overhaul Other		Repair Supply Other	
	75	76	75	76	75	76	75	76	75	76
J79GE8	1310	1330	680	590		350				
J79GE10	1320	1330	700	640		850				
T58GE3A/F							500	500	235	200
T58GE5A/F							500	500	290	230
T58GE8B				290			390		180	230
T58GE8F	510	510	360	310						
T58GE10	560	520	330							300
T64GE6B	640	730	400	400						
T64GE7A/F							640	720	340	250
T64GE10										300
T64GE413/15										
T64GE413	650	700	400							310
T64GE415								700		
LM1500PF102							1330	1400		

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